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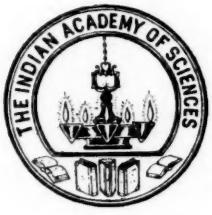
OF THE

INDIAN ACADEMY

OF SCIENCES

VOL. XVII] *SECTION A* [NO. 1

JANUARY, 1943



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PRINTED AT THE BANGALORE PRESS, BANGALORE CITY, BY G. SRINIVASA RAO, SUPERINTENDENT, AND PUBLISHED BY THE INDIAN ACADEMY OF SCIENCES, BANGALORE.

Physics
Indian Academy of Sciences
10-15-43
47604

CONDENSATION OF MALONANILIC ACID WITH ALDEHYDES

Part V. With *o*- and *p*-Chlorobenzaldehydes and *m*-Bromobenzaldehyde: the Influence of the Halogens

By Kantilal C. Pandya and (Miss) Rashmi Bala Pandya
(*Chemistry Department, St. John's College, Agra*)

Received November 23, 1942

In Part I of this series[1] the use of a trace of pyridine or piperidine, found so interesting in aldehyde-malonic acid condensations,[2] was extended to aldehyde-malonanilic acid condensations and was found to give, on the whole, very much larger yields than those obtained by the pyridine-piperidine-mixture method. In Part II[3] it was shown that the condensation-reaction is very much influenced by two factors, *viz.*, the presence or the absence of pyridine and by the nature of the group present on the ring of the aromatic aldehyde, and also according to its position with regard to the aldehyde group. This latter observation was further corroborated in Parts III[4] and IV,[5] wherein the influence of the hydroxy,[4] the nitro[5] and the methyl groups[6] was described. In the present paper are described the observations indicating the influence of the halogens, chlorine and bromine, when present on the ring with the aldehyde.

The whole subject of aldehyde-malonic acid condensation is thus capable of being investigated and reviewed under three distinct heads :—

i. The influence of the presence or absence of pyridine.

ii. The influence of the various groups and their positions on the aromatic ring of the aldehyde.

iii. The influence of the groups on the acid molecule, *i.e.*, the groups combined with the reactive methylene.

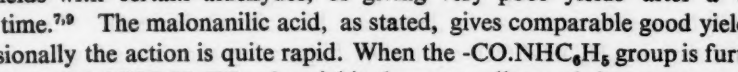
Regarding i, it may be stated that, as observed by earlier workers also, condensation does take place in the entire absence of pyridine or any other condensing reagent. But it is exceedingly slow: quantitative yields, however, are obtainable under carefully controlled conditions[7]: the product, in the case of malonic acid, is generally the dibasic acid derivative of malonic acid, and, in the case of malonanilic acid, the corresponding derivative of that acid. The use of a trace of pyridine, in both the condensations,

not only speeds up the condensation, but gives excellent yields, of high purity, often in quantitative proportions, and further causes decarboxylation, the product in each case having lost one molecule of carbon dioxide. The malonic acid and malonanilic acid condensations are in this respect very similar.

Regarding ii also the two condensations appear to be comparable. The influence of groups is seen when results and yields are compared with those obtained with unsubstituted benzaldehyde and malonic or malonanilic acid. The hydroxy group, particularly in the ortho-position to the aldehyde group, exerts the most depressing effect in both the condensations, but yields very greatly improve when the hydroxy group is in the *m*- or the *p*-position. There is a further improvement in the case of the methyl (only the *p*-methyl investigated so far[6]) and the methoxy groups ; the latter group, when in the *m*- and *p*-positions, give, in the presence of pyridine, over 90% yields. The nitro group gives quantitative yields when in *m*- and *p*-positions, while the yield is still very high, but definitely less, about 70%, when it occupies the ortho-position.

The chloro- and the bromo-groups had given a very striking increase in the aldehyde-malonic acid condensation[7] as well as in the Perkin's condensation-method[8] : in the aldehyde-malonanilic acid condensation the same effect is seen, though without the same uniformity, the yields from the *p*-chlorobenzaldehyde falling even a little below that obtained from benzaldehyde. The highest yield about 99% is obtained from *m*-bromobenzaldehyde; *vide* Table.

Regarding iii, the observation might have been, but was not quite, expected. It was first made when the malonic ester behaved differently from the malonic acid, ethyl malonate giving, under identical conditions, either no yields with certain aldehydes, or giving very poor yields after a very long time.[7,9] The malonanilic acid, as stated, gives comparable good yields : occasionally the action is quite rapid. When the -CO.NHC$_6$H$_5$ group is further altered to CO NHC$_6$H$_4$CH$_3$, the yields show an all-round improvement, as shown by the condensations of *o*-, *m*- and *p*-malon-toluidic acids (still unpublished, Ittyerah). Thus there is a perceptible difference in the reactivity of the methylene group itself according to what its distant neighbours are :



Experimental

Condensation of p-Chlorobenzaldehyde in the presence of a trace of Pyridine : p-Chlorobenzylidene-malonanilic acid and p-Chlorocinnamanilide.

1·4 g. Malonanilic acid, 1·8 g. *p*-chlorobenzaldehyde and 0·14 c.c. pyridine (1 : 1 : 0·16 mol.) were heated together in a flask on water-bath. The mixture became a homogeneous liquid in about ten minutes and effervescence started after another ten minutes. The heating was continued for four hours. On cooling a dirty yellow solid was seen, which did not liquefy when the flask was again heated on the water-bath on the next day. Treatment with sodium carbonate solution removed only a part of the product. The remaining cinnamanilide, separated by filtration, was washed, first with water and then with ether to remove any unreacted aldehyde : at the end of this, it came out as a colourless solid weighing 1·8 g. and melting at 172°. On recrystallisations from alcohol, it came out in long colourless needles. After being air-dried for some hours, they melted at 180°. (Yield about 70%.) It decolourised Baeyer's reagent.

The *p*-chlorobenzylidene-malonanilic acid was recovered from the sodium carbonate extract by acidification, when it came down as a white solid, melting between 180–90°. Recrystallisation from dilute alcohol or benzene made it melt sharp at 190°. (Yield about 6%.)

Condensation in the absence of any condensing agent.

0·9 g. Malonanilic acid and 0·7 g. *p*-chlorobenzaldehyde were heated as before on the water-bath for eight hours, when a green solid was left on cooling. It was extracted with 10% sodium carbonate solution when the bulk of it went into solution leaving only a small amount of a greenish blue powder. This was filtered off and dried: on melting it became colourless, or it melted to a colourless liquid. On purification by alcohol it became colourless and melted at 180°, being identical with the cinnamanilide described above. (Yield 8%.)

The sodium carbonate extract, when acidified, also gave a light blue coloured solid melting at 190–200°. A second treatment with a quantity of sodium carbonate solution, followed by acidification, gave a colourless solid, which on the usual crystallisation melted at 192°. Though colourless when freshly crystallised, it became bluish on exposure to air in a moist condition : it also became blue just before melting and the hot melt was also bluish. The melting was accompanied with effervescence. (Yield = 66%.)

p-Chlorocinnamanilide : Found Cl = 13·63%; $C_{15}H_{12}ONCl$ requires 13·79%.

p-Chlorobenzylidenemalonanilic acid : Found: Cl = 11·28%, $C_{16}H_{12}O_3NCl$ requires 11·77%. Molecular weight, Found = 304·3; required 30 ·5.

Condensation with o-Chlorobenzaldehyde : *o-Chlorobenzylidene-malonanilic acid and o-Chlorocinnamanilide. In the presence of a trace of Pyridine.*—1·79 g. malonanilic acid, 1·40 g. *o*-chlorobenzaldehyde and 0·14 c.c. pyridine were heated as usual on a water-bath for four hours. There was considerable effervescence and a solid began to be formed within the first hour. The anilide and the acid were separted as before. The yields were, the acid = 13%, and the cinnamanilide = 70%. In another condensation piperidine replaced pyridine, when on three hours' heating nearly the same yields were obtained: acid = 6·6%, and the anilide = 70%.

Without any Catalyst.—2·7 g. Malonanilic acid and 1·4 g. *o*-chlorobenzaldehyde were heated together on a water-bath: a solid with a greenish tinge started coming out within the first hour and the action appeared to have been completed in three hours in all, when the heating was stopped. Only a small amount of cinnamanilide (about 2-4%) was obtained, while the acid came out in nearly theoretical yield.

Crude *o*-chlorobenzylidenemalonanilic acid was fairly pure, melting at about 220°: after recrystallisation from alcohol the melting-point remained unchanged at 225°. Found: Cl = 11·99%, required 11·77%. Found: Molecular weight by titration = 300.6, required = 301·5.

The crude *o*-chlorocinnamanilide melted over a long range, 150–70°. Recrystallisation from different solvents and refluxing the alcoholic solution with animal charcoal, filtering and cooling gave the first crop melting at 176° (recrystallised from ethyl acetate, m.p. 176–77°). A second crop came out from alcohol, which, after repeated recrystallisations from alcohol, melted at 149–50°, which rose to 153-54° when the crystallisations were repeated with hot ethyl acetate. It was clear that both were cinnamanilides: analysis gave Cl, in the higher melting, found = 13·68%, in the lower melting, found = 13·98% : required = 13·79%.

Moreover, when a small quantity of the *o*-chlorobenzylidenemalonanilic acid was carefully decarboxylated by a gentle heating for a short time just above the melting point, effervescence took place, the melted liquid turned yellow first and then green, a small part undergoing decomposition. After removing the decomposed portion, the clear residue was found to be a mixture of the two, separable into the two forms already obtained and identifiable with them by the mixed-melting-point method.

Condensation with m-*Bromobenzaldehyde*: m-*Bromobenzylidene-malonanilic acid and* m-*Bromocinnamanilide*: *In the presence of a trace of pyridine.*—0·92 g. *m*-Bromobenzaldehyde, 0·9 g. malonanilic acid and 0·07 c.c. pyridine were heated together on a water-bath. Effervescence was observed, but no

solid came out when the heating was stopped after four hours. It was left overnight and treated in the usual way next morning, though the solid product was not washed with ether as it was completely soluble in ether. After washing with water it was taken on a porous plate and dried. The crude cinnamanilide melted at 112-20° : recrystallised from alcohol, the m.p. rose to 128-29°. Yield = 87%, with only a trace of the acid. In another and more careful experiment, the product came out as a highly viscous liquid which on keeping in water became solid. No acid was obtained from the sodium carbonate washing and extract, but the yield of the cinnamanilide was over 99%.

In the absence of any condensing agent.—1·79 g. malonanilic acid and 1·85 g. *m*-bromobenzaldehyde were heated together on water-bath for eight hours. After four hours a green solid had started coming out. Treatment with sodium carbonate dissolved the main portion of the product, though without effervescence. About 10% (the cinnamanilide) was left undissolved, which was repeatedly treated with sodium carbonate solution and finally separated. On recrystallisation, however, it melted at a very much higher temperature, namely at 162°, instead of at 128-29°. The filtrate containing the sodium salt was shaken up with ether to remove any aldehyde still remaining, and acidified, when the bromobenzylidenemalonanilic acid came down as a green precipitate. On recrystallisation from alcohol, it melted at 186–88°. (Yield = 72%.) The pure acid came out in colourless needles.

The lower-melting cinnamanilide gave : Found Br = 26·30 : $C_{15}H_{12}$-ONBr requires 26·49%. The higher-melting was too little for analysis and no more of the bromobenzaldehyde was obtainable. The *m*-bromobenzylidenemalonanilic acid : Found Br = 22·9% : $C_{16}H_{12}O_3NBr$ requires 23·1%.

Summary

The condensation of malonanilic acid with *o*- and *p*-chloro- and *m*-bromobenzaldehydes is described. The reaction is fairly rapid and gives very good yields. The products, in the absence of any catalyst and in the presence of a trace of pyridine, are in a line with those obtained from other aromatic aldehydes. The production of isomeric *o*-chlorocinnamanilides, and probably of two isomeric *m*-bromocinnamanilides, in these condensations is rather remarkable. The influence of the halogen, chlorine and bromine groups, in the positions mentioned, is as uniform as was noticed in the aldehyde-malonic acid condensations.

TABLE

The heating was throughout on water-bath, though the hours of heating were not always identical : usually five hours, about one to two for the nitro and much more for the hydroxy.

Aldehyde	Yields % with a trace of base			Without any		
	Anilide	Acid	Total	Acid	Anilide	Total
Benzaldehyde	89·7	0	89·7	86·0	0	86·0
o-Hydroxy-	37·8	0	37·8	30·2	0	30·2
m- „	79·6	0	79·6	52·0	0	52·0
p- „	79·6	0	79·6	18·0	0	18·0
p-Methyl-	71·7	0	71·7			
Piperonal	56·2	3·7	59·9			
o-Methoxy-	84·6	0	84·6	26·7	46·1	73·8
m- „	92·3	0	92·3	26·7	53·8	80·5
p- „	92·3	0	92·3	47·0	23·0	70·0
o-Nitro-	70·9	0	70·9	32·1	37·7	69·8
m- „	67·0	0	67·0	30·2	70·7	100
p- „	74·6	0	74·6	77·2	22·4	99·6
p-Chloro-	70·0	6	76	66·3	8	74·3
o- „	·70	13	83	90	0	90
m-Bromo-	99	0	99	72·3	10	82·3

REFERENCES

1. Mehra and Pandya .. *Proc. Ind. Acad. Sci.*, 1938, **7**, 369.
2. Pandya and collaborators .. *J. Ind. Chem. Soc.*, 1934, **2**, 823 ; *Proc. Ind. Acad. Sci.*, 1935, **1**, 440, and subsequent numbers.
3. Ittyerah and Pandya .. *Ibid.*, 1941, **13**, 119.
4. ———— .. *Ibid.*, 1941, **13**, 122.
5. ———— .. *Ibid.*, 1941, **13**, 461.
6. Mehra and Pandya .. *Ibid.*, 1939, **9**, 510.
7. Pandya and Miss Pandya .. *Ibid.*, 1941, **13**, 112.
8. Lock and Bayer .. *Ber.*, 1939, **72**, 1064.
9. Kurien, Pandya and Peter .. *Proc. Ind. Acad. Sci.*, 1935, **1**, 775.

ALUMINIUM CHLORIDE, A NEW REAGENT FOR THE CONDENSATION OF β-KETONIC ESTERS WITH PHENOLS

Part VI. The Condensation of Resacetophenone with Ethyl α-Alkyl-Acetoacetates

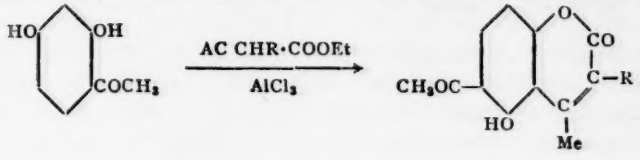
BY C. V. DELIWALA AND N. M. SHAH

(From the Department of Chemistry, M. R. Science Institute, Gujarat College, Ahmedabad)

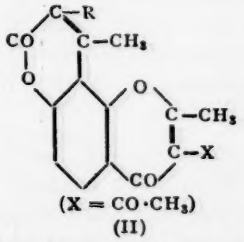
Received January 20, 1942

(Communicated by Prof. R. C. Shah, M.SC., PH.D., F.N.I., F.A.SC.)

IN continuation of the previous work published in the earlier parts of this series,[1–4] this paper describes further investigations carried out mainly to study the effect of substitution in the acetoacetate molecule on its condensation with resacetophenone in presence of aluminium chloride. We have successfully condensed resacetophenone with ethyl α-methyl-, α-ethyl- and α-benzyl-acetoacetates. In each case, the product obtained is 5-hydroxy-6-acetyl-3-alkyl-4-methylcoumarin (I; R = CH_3, C_2H_5, $-CH_2Ph$ respectively).



(I)



(X = CO·CH_3)

(II)

On Kostanecki acetylation, (I) gives the corresponding chromono-α-pyrones (II). The product (I ; R = Me) was converted into its corresponding cinnamic acid, 2 : 6-dimethoxy-3-acetyl-αβ-dimethylcinnamic acid.

Attempts to similarly condense resacetophenone with ethyl α-propyl-, α-allyl-, α-phenyl- and α-chloro-acetoacetates were not successful.

It has been already pointed[4] out that aluminium chloride and phosphorus oxychloride are the efficient condensing agents for the condensation of unsubstituted acetoacetic ester with phenolic ketones. An attempt was therefore made to condense resacetophenone with α-methylacetoacetate using $POCl_3$ according to Desai and Hamid,[6] but no condensation product was obtained.

The results show that while no condensation takes place using phosphorus oxychloride, the introduction of α-alkyl substituent in the acetoacetic ester is not so inhibitive if aluminium chloride is used. With aluminium chloride, it is found that negative substituents in the α-position have a completely inhibitory effect on the reaction. But if the substituents are positive, their inhibitory effect is small. Even here the yield depends upon the bulk of the substituent.

Experimental

Condensation of resacetophenone with ethyl α-methylacetoacetate in presence of anhydrous aluminium chloride: Formation of 5-hydroxy-6-acetyl-3: 4-dimethylcoumarin.—Resacetophenone (9 g. : 1 mol.) and ethyl α-methyl acetoacetate (8·5 g. : 1 mol.) were added to a solution of aluminium chloride (16 g. : 2 mols.) in dry nitrobenzene (80 c.c.), the mixture being protected from moisture by $CaCl_2$ guard-tube. It was heated for nearly one hour at 120–130° on oil-bath : HCl fumes were copiously evolved. After the evolution of the acid fumes had slackened, the reaction-mixture was cooled ; crushed ice and conc. HCl (10 c.c.) added ; the nitrobenzene was distilled off in steam. After the removal of nitrobenzene, a brown mass was obtained. It was removed and the liquid on cooling deposited crystals which proved to be unchanged resacetophenone. The brown mass was triturated with little alcohol, which removed the coloured impurities. The white solid obtained crystallised from alcohol, thin long needles, m.p. 209-210°; yield, about 1g. (Found: C, 67·25 ; H, 5.5. $C_{13}H_{12}O_4$ requires C, 67·23; H, 5·2. per cent.)

The *coumarin* dissolves in alkali with yellow non-fluorescent[5] colour and gives reddish brown coloration with alcoholic ferric chloride solution. It is soluble in hot glacial acetic acid, chloroform and benzene ; sparingly so in alcohols and insoluble in light petroleum-ether. The *acetyl* derivative prepared by refluxing the coumarin (0·5 g.) with acetic anhydride (3 c.c.) and pyridine (4–5 drops) for more than five hours on water-bath and keeping the mixture overnight, crystallised from dil. alcohol, stout needles, m.p. 105–106°. (Found : C, 65·6; H, 5·3. $C_{15}H_{14}O_5$ requires C, 65·7 ; H, 5·1 per cent.) The *oxime* prepared as usual, crystallised from acetic acid, lustrous crystals, unmelted to 245°.

Conversion of the above coumarin into 2:6-*dimethoxy*-3-*acetyl*-α*β*-*dimethyl-cinnamic acid.*—To the coumarin (1 g.) dissolved in a small quantity of acetone, dimethyl sulphate (10 c.c.) was added; caustic potash (20 c.c. 20 per cent.) solution was slowly mixed and the solution well shaken. It was then refluxed on boiling water-bath for a few minutes. More alkali (in all 40 c.c.) and dimethyl sulphate (5 c.c.) were added at intervals and the refluxing continued for an hour and half. It was then cooled, acidified with dil. HCl and extracted with ether; the ether extract treated with $NaHCO_3$ solution (5%) and the bicarbonate layer separated and acidified. The acid which separated was crystallised from water, m.p. 158–159°. (Found: C, 64·9; H, 6·7. $C_{15}H_{18}O_5$ requires C, 64·8 : H, 6·5 per cent.)

Kostanecki acetylation of 5-*hydroxy*-6-*acetyl* 3 : 4-*dimethylcoumarin* : *Formation of* 2′ : 3 : 4-*trimethyl*-3′-*acetyl-chromono*-7′ : 8′ : 6 : 5-α-*pyrone.*—The coumarin (1 g.) was refluxed with acetic anhydride (10 c.c.) and fused sodium acetate (2 g.) for nearly 12 hours on oil-bath at 160–170°. The reaction-mixture was cooled, poured into cold water and the solid obtained was treated with Na_2CO_3 solution and then thoroughly washed with water ; crystallised from alcohol, fine granules, m.p. 205–206°. (Found: C, 68·6; H, 5·2. $C_{17}H_{14}O_5$ requires C, 68·4 ; H, 4·7 per cent.) The chromono-α-pyrone is insoluble in alkali and gives no ferric chloride test.

Condensation of resacetophenone with ethyl α-*ethyl-acetoacetate: Formation of* 5-*hydroxy*-6-*acetyl*-3-*ethyl*-4-*methylcoumarin.*—The mixture of resacetophenone (3 g.) and α-ethyl-acetoacetate (3 g.) purified according to Sethna and Shah[7] was added to the solution of anhydrous aluminium chloride (5·5 g.) in dry nitrobenzene (25 c.c.) and heated as before, and the reaction-mixture worked up similarly. The brown oil obtained solidified on cooling. It was twice crystallised from alcohol, needles, m.p. 158–59°. (Found : C, 68·0 ; H, 5·9. $C_{14}H_{14}O_4$ requires C, 68·3; H, 5·7 per cent.) The *coumarin* dissolves in alkali with deep yellow without any fluorescence and gives red colour with alcoholic ferric chloride. The *acetyl* derivative prepared as before (refluxing for more than 6 hours) crystallised from alcohol, m.p., 119–120°. (Found: C, 66·3; H, 5·7. $C_{16}H_{16}O_5$ requires C, 66·3; H, 5·5 per cent.)

Condensation of resacetophenone with ethyl α-*benzyl-acetoacetate*: *Formation of* 5-*hydroxy*-6-*acetyl*-3-*benzyl*-4-*methylcoumarin.*—Resacetophenone (3 g.) and α-benzyl acetoacetic ester (4·5 g.) were added to the solution of aluminium chloride (5·5 g.) in dry nitrobenzene (30 c.c.) as in the previous cases and reaction-mixture worked up similarly. The solid obtained crystallised from alcohol, needles, m.p. 186–87°. (Found: C, 74·1; H, 5·4. $C_{19}H_{16}O_4$

requires C, 74·0; H, 5·2 per cent.) The coumarin is insoluble in alkali but turns deep yellow in alcoholic alkali and develops red colour with alcoholic ferric chloride. The *acetyl* derivative prepared as before crystallised from alcohol, clusters of soft silky needles, m.p. 147–48°. (Found: C, 71·85; H, 5·0. $C_{21}H_{18}O_5$ requires C, 72·0 ; H, 5·1 per cent.) The *oxime* prepared as usual crystallised from alcohol, lustrous silvery white leaflets., m.p. 250–51° (decomp).

Kostanecki acetylation of the above coumarin : Formation of 2′: 4-dimethyl-3′-acetyl-3-benzyl-chromono-7′ : 8′ : 6 : 5-α-pyrone.—The coumarin (1 g.) was mixed with acetic anhydride (20 c.c.) and fused sodium acetate (2 g.), and the mixture refluxed on oil-bath for about 11 hours at 160–70°, and worked out as before : crystallised from alcohol, reddish yellow fine granules, m.p. 181–82°, the mixed m.p. with the original coumarin being lowered to 165°. (Found: C, 73·7; H, 4·6. $C_{23}H_{18}O_5$ requires C, 73·8 ; 4·8 per cent.)

Our sincere thanks are due to Mr. N. Ghosh, M.Sc., and to Dr. D. Chakravarti, Calcutta, for micro-analysis. We thank Principal G. R. Paranjpe for a gift of α-ethyl-acetoacetate, and Dr. R. C. Shah for his sympathetic interest.

Summary

The condensation of resacetophenone with several α-substituted aceto-acetates with anhydrous aluminium chloride as condensing agent has been investigated. Ethyl α-methyl-, α-ethyl-, α-benzyl-acetoacetates undergo the condensation with the formation of 5-hydroxy-6-acetyl-3-alkyl-coumarin derivatives. Negative results were obtained with ethyl α-propyl-, α-allyl, α-chloro-acetoacetates, the original ketone being recovered. The results obtained have been discussed.

REFERENCES

1. Sethna, Shah and Shah .. *J.*, 1938, 228.
2. Shah and Shah .. *Ibid.*, 1938, 1424.
3. Deliwala and Shah .. *Ibid.*, 1939, 1250.
4. ———— .. *Proc. Ind. Acad. Sci.*, 1941, **13** *A*, 352.
5. Collie and Chrystall Dey .. *J.*, 1907, **91**, 1804.
.. *Ibid.*, 1915, **107**, 1614, 1621.
6. Desai and Hamid .. *Proc. Ind. Acad. Sci.*, 1938, **8** *A*, 567.
7. Sethna and Shah .. *J. Indian C. S.*, 1938, **15**, 383.

THE ISOLATION AND CONSTITUTION OF AN ACID FROM THE ROOT BARK OF *IXORA COCCINEA* (*LINN.*)

By A. R. Sukumaran Kartha and K. N. Menon

(*Maharaja's College, Ernakulam*)

Received November 21, 1942

Ixora coccinea is a small hardy shrub found all over the hilly parts of India. It seldom grows above a couple of feet in height and bears flowers and fruits throughout the year. It finds various uses in Indian (Ayurvedic) Medicine and all authoritative treatises insist upon using only the fresh root bark. In the course of this investigation it was found that the light petrol extractive portion of the drug is seriously affected either on storage or on drying in the sun.

The light pertol extract was a liquid acid free from glycerides, and was easily resinified either by heating or by prolonged treatment with alcoholic alkali. It gave no solid derivatives and decomposed with resinification when distilled under reduced pressure. The alkyl ester was readily obtained and could be easily purified by distillation. Careful fractionation revealed the existence of only one ester. The ethyl ester analyses for the formula $C_{17}H_{31}COOC_2H_5$, and on reduction (Adam's catalyst) afforded ethyl stearate, $C_{17}H_{35}COOC_2H_5$. No solid tetrabromide of the unreduced acid or its ester could be isolated although the theoretical quantity of bromine was absorbed. The free acid also gave stearic acid on reduction proving its straight chain character and the existence of two double bonds. On oxidation of the acid with aqeuous permanganate, no tetraoxy stearic acid could be obtained. In fact, under the conditions employed for the oxidation of linoleic to tetraoxy stearic acid, only azelaic acid and a resin could be obtained. The resin gave no tangible products. Cold permanganate oxidation of the ester in acetone gave azelaic acid, oxalic acid and heptoic acid. On the basis of this oxidation and reduction to stearic acid, the acid is assigned the constitution (I).

$$CH_3-(CH_2)_5-CH=CH-CH=CH-(CH_2)_7-COOH.$$

(I)

A search of the literature showed that Chonowsky[1] obtained a synthetic acid to which the above constitution may be assigned. Chenowsky obtained a di-iodostearic acid, $C_{18}H_{34}O_2I_2$, by the action of hydriodic acid

ricinoleic acid. When this di-iodo acid was treated with alcoholic potash, a $C_{18}H_{32}O_2$ acid was obtained. This acid is reported to be very difficult to purify and on oxidation with aqueous permanganate only azelaic acid could be obtained. The course of dehalogenation can give rise to either (I) or an acid of the formula (II).

$$CH_3 - (CH_2)_4 - CH = CH - CH_2 - CH = CH - (CH_2)_7 - COOH.$$

(II)

No attempt has been made by Chenowsky to differentiate between the alternate formulæ and as azelaic acid is the only oxidation product isolated, the constitution of one half of the molecule remains obscure.

The isolation of heptoic, oxalic and azelaic acids by the oxidation of the ester of the acid from ixora, and the reduction of the acid to stearic acid rigidly establishes the constitution (I) assigned to it. Probably this is the first instance of isolation from natural sources of a polyethenoid straight chain acid with one conjugate double bond. In the vegetable kingdom, as far as the authors are aware, polyethenoid unsaturation is confined to the acids of the C_{18}-series and the structure of the acids is generically similar to, linoleic and pertoselanic acids. These acids can be further divided into two groups (*a*) conjugated and (*b*) non-conjugated. Recently Hilditch, Meara and Zaky[2] have reported the isolation of a C_{19} unsaturated polyethenoid acid from the fatty acids of *Sterculia foetida* oil. Considerable difficulty was experienced by these authors in the isolation and purification of their acid, an experience which finds a close parallel in the case of the acid from ixora. The C_{19}-unsaturated acid was converted into the methyl ester and was oxidised with permanganate in acetone yielding methyl *n*-hexyl ketone, heptoic acid and azelaic acid. A very small amount of another dibasic acid, which was extremely soluble in water, was also produced, but the acid was not definitely characterised. The presence of methyl *n*-hexyl ketone (and heptoic acid) in the oxidation products defines the point at which unsaturation commences in the unusual C_{19} acid, and further shows that it is an unsaturated derivative of 12-methyl stearic acid. With conjugated diethenoid unsaturation, the constitution of the acid would be 12-methyl-Δ^{9-11}-octadecadienoic acid. The acid from ixora is the lower homologue, Δ^{9-11}-octadecadienoic acid.

Synthetical experiments in this group of fatty acids are in progress. Working with large quantities of the acid, a small percentage (0·4%) of myristic acid could be isolated during the purification of the main constituent. Myristic acid is, therefore, a minor constituent of the

petrol-soluble portion of the root bark extract. Nothing of a water-soluble character seems to exist in the petroleum extract of the root bark.

The root bark, after exhaustion with petrol, gave with alcohol, a difficult mixture of substances from which mannitol was isolated.

Experimental

Fresh root bark contains 15% of moisture. 56 Grams of the air-dried bark was hot extracted with various solvents in succession, with the following results :—

(1) Light petrol (40–60)	yielded 5·6 grams	or 10 %
(2) Ether	0·05	0·1 %
(3) Chloroform	0·35	0·7 %
(4) Ethyl acetate..	0·15	0·3 %
(5) Alcohol	3·86	7·0 %

The light petrol extract goes completely into solution in 90% alcohol, and dissolves completely in cold dilute potassium carbonate (quickly on warming) solution with effervescence, thus showing that it is an acid and not a glyceride. On acidifying the carbonate solution with dilute sulphuric acid, the whole of the original acid is thrown down. The acid, thus precipitated, yields a methyl ester of the same boiling point as the ester from the untreated acid. The original liquid acid was subjected to a lead salt separation in order to free it from a very small portion of impurity. The regenerated liquid acid was esterified by refluxing with alcoholic sulphuric acid and then purified by reduced pressure distillation. (Methyl ester 195–96/5 mm. and ethyl ester 215–16°/5 mm.)

(1) 0·0253 gm. gave 0·0722 gm. CO_2 and 0·0255 gm. H_2O
(2) 0·0281 gm. gave 0·0804 gm. CO_2 and 0·0286 gm. H_2O

Hence	Carbon ..	78·02 %	78·03 %
	Hydrogen ..	11·22 %	11·35 %
	Oxygen ..	10·76 %	10·62 %

$C_{17}H_{31}COOC_2H_5$ requires C, 77·91% ; H, 11·69% and O, 10·49%.

2·8869 grams of the ester required 18·75 c.c. of N/2 KOH for saponification corresponding to a saponification equivalent of 307·9.

Myristic acid, isolated by fractional distillation of the ester from the untreated acid, was identified by equivalent weight determination, and mixed melting points of the free acid and the phenacyl ester.

Oxidation of the ester.—37 Grams of the ester was dissolved in about 700 c.c. of purified acetone and oxidised with finely powdered permanganate (12 times the weight of the ester), the temperature being maintained below 6° C.; oxidation being completed at 10–15°. The acetone was removed by filtration and on distilling, using a long column, yielded nothing appreciable. The manganese dioxide sludge was repeatedly extracted with boiling water and the combined aqueous extracts reduced to a small volume on the water-bath. The concentrate was acidified and then steam-distilled. The distillate was saturated with common salt and repeatedly extracted with ether. The combined ethereal solution, dried over anhydrous magnesium sulphate, gave a sweet smelling acid, which was converted into its ethyl ester (b.p. 66–67°/10 mm.). The purified ester was hydrolysed with alcoholic potash and the acid recovered.

4·0014 Grams of the acid required 67·80 c.c. of 0·456 N. KOH. Hence the molecular weight is 129·2 corresponding to heptoic acid, 130. The identification was further confirmed by preparing the phenyl phenacyl ester (m.p. 62°).

The non-steam volatile acid solidified on cooling and crystallised from alcohol melting at 108°. It was identified as azelaic acid by mixed melting point as well as by the mixed melting point of the phenyl phenacyl ester (m.p.141°).

The aqueous liquor from which azelaic acid was completely removed, was made alkaline with ammonia and then treated with calcium chloride. The precipitate obtained was insoluble in acetic acid and on decomposition gave oxalic acid (m.p. 101·6°).

Catalytic reduction.—25 grams of the ethyl ester was dissolved in 200 c.c. of glacial acetic acid and reduced with hydrogen in presence of platinum oxide catalyst. The absorption of hydrogen was rapid at first and the solution warmed up. Gradually the flask cooled and the absorption became slower. On standing overnight, a crystalline solid separated. The reduction was continued for 5–6 hours more to ensure complete conversion. After reduction was complete, the flask was heated on the water bath, and the clear solution filtered, poured into water, extracted with ether, and the ester recovered. It came over completely at 194–96°/5 mm. The distillate solidified to a hard white crystalline mass melting at 40°. The free acid obtained by the hydrolysis of the reduced ester melted, after crystallisation from acetone, at 71–72°. A mixed melting point with an authentic specimen of stearic acid showed no depression. The phenacyl ester melted

at 59°, and showed no depression when mixed with an authentic specimen of phenacyl stearate.

Isolation of mannitol.—The bark, exhausted with light petrol, was extracted with 90% alcohol. The extract was freed from alcohol and the residue treated with hot water. The aqueous extract was clarified with lead acetate, excess of lead removed by hydrogen sulphide, and the resulting solution concentrated to a syrup on the water-bath. The crystalline berri formed on cooling was triturated with 95% alcohol, the crystals collected and crystallised from alcohol. It formed feathery needles melting at 170° and showed no depression with an authentic specimen of mannitol. The tribenzal derivative melted at 224° and was not depressed with an authentic specimen of tribenzal mannitol.

Summary

The root bark of *Ixora coccinea* contains a liquid acid, identified as Δ^{9-11}-octadecadinoic acid and mannitol.

REFERENCES

1. *Ber.*, 1909, **42**, 3339.
2. *J.S.C.I.*, 1941, **60**, 202.

SYNTHETIC EXPERIMENTS IN THE BENZOPYRONE SERIES

Part VII. Some Stages in the Synthesis of Karanjin

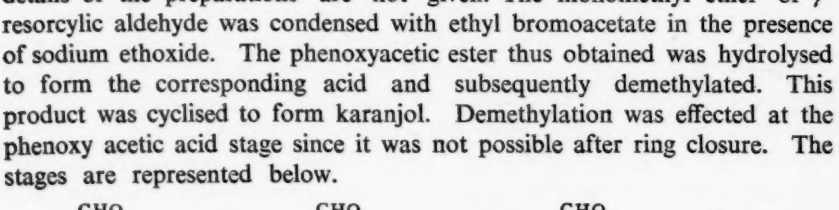
By T. R. Seshadri and V. Venkateswarlu

(From the Department of Chemistry, Andhra University, Waltair, now at Guntur)

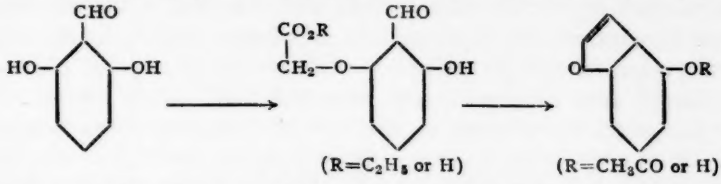
Received November 12, 1942

Experiments relating to the synthesis of the karanjin skeleton starting from 7-hydroxy-3-methoxy-flavone were described in Parts I and II[1] of this series of papers. Karanjin itself could not be obtained through them. The alternative route which involves the building up of the flavone ring system from the required hydroxy-coumarone worked smoothly and this was described in Part IV.[2] Karanjic acid was converted into ω-methoxy-acetyl karanjol and from this ketone karanjin could be obtained by condensation with benzoic anhydride and sodium benzoate. The earlier stages leading to the synthesis of karanjic acid are examined in this communication and a new convenient procedure is described.

4-Hydroxycoumarone (karanjol) was first prepared by Reichstein[3] who heated together an intimate mixture of freshly distilled furfural, dried sodium succinate and acetic anhydride. Besides other compounds he could obtain as one of the products 4-hydroxycoumarone in low yield. Subsequently Limaye[4] adopted a more direct method; in his short note on this subject details of the preparations are not given. The monomethyl ether of γ-resorcylic aldehyde was condensed with ethyl bromoacetate in the presence of sodium ethoxide. The phenoxyacetic ester thus obtained was hydrolysed to form the corresponding acid and subsequently demethylated. This product was cyclised to form karanjol. Demethylation was effected at the phenoxy acetic acid stage since it was not possible after ring closure. The stages are represented below.



This procedure seemed to be capable of simplification. The more easily accessible γ-resorcylic aldehyde[5] could be used directly and thus methylation and subsequent demethylation involving large losses could be avoided. It has now been condensed with bromoacetic ester in the presence of sodium ethoxide under controlled conditions. The synthesis may be represented as follows :—



The phenoxyacetic ester was hydrolysed to the acid and ring closure and decarboxylation were effected by boiling the acid with acetic anhydride. Karanjol acetate was thus produced and hydrolysed to karanjol. For the preparation of karanjic acid from karanjol two methods were adopted by previous workers. Limaye[6] heated the hydroxy compound with aqueous sodium bicarbonate in a sealed tube. Harper[6] treated it with sodium methoxide and methyl alcohol in a distilling flask and heated the mixture in a rapid current of carbon deoxide to 170°. The second method is found to be not only more convenient to operate, but it gives rise to a good yield of a pure sample of the acid.

Experimental

Condensation of γ-resorcylic aldehyde with ethyl bromoacetate : Ethyl-2-aldehydo-3-hydroxyphenoxy-acetic acid.—γ-resorcylic aldehyde (1·0 g., 1 mol.) dissolved in absolute ethyl alcohol (20 c.c.) was treated with sodium ethoxide in alcohol (0·167 g. of sodium-1 atom-in 20 c.c. of alcohol) and ethyl bromoacetate (0·9 c.c.) and the mixture refluxed for 3 hours. At the end of this period, it was found that the solution was practically neutral to litmus. The contents were then transferred to a basin and the solvent and unreacted ethyl bromoacetate allowed to evaporate slowly at the laboratory temperature. The brown viscous liquid left behind did not crystallise when kept in the ice chest and was insoluble in aqueous sodium carbonate. It gave a reddish brown colour with alcoholic ferric chloride and regenerated the colour of the Schiff's reagent. From these it could be concluded to be the required ester having free phenolic and aldehydo groups ortho to each other. It was directly subjected to hydrolysis without further purification.

Hydrolysis of the ester : 2-Aldehydo-3-hydroxy-phenoxy-acetic acid.—Boiling with caustic soda solution was found to be unsuitable since resinification took place and there was almost complete loss. The following

procedure was therefore adopted. The above ester was treated with excess of cold sodium hydroxide (20 c.c. of 10% solution) and allowed to stand at room temperature for about 45 hours. The clear reddish brown solution was treated with excess of dilute hydrochloric acid at 0° C. A light brown solid product separated out. However, the whole mixture was repeatedly extracted with ether. The ether extract was then shaken up with aqueous sodium bicarbonate (4% solution) till no more could be extracted. The acid was regenerated from the aqueous solution by the addition of excess of hydrochloric acid and was again extracted with ether. Much of the impurities could be removed by the above treatment with bicarbonate. However, on evaporating the ether solution a light brown liquid was obtained and it could not be crystallised easily. Further pruification was therefore effected by the following method: The viscous liquid was dissolved in dry acetone (10 c.c.) and petroleum ether (B.P. about 60° C.) was then added to the solution until the supernatant liquid was clear and colourless. It was decanted from the brown deposit of impurities and was allowed to evaporate slowly when a light yellow crystalline solid began to separate out. Final crystallisation was effected from alcohol when the acid came out in the form of colourless rectangular plates melting at 176-77°, the melting point given by Limaye for the same being 175°. The acid gave the same colour reactions as the ester. (Found : C, 55·3 ; H, 4·3 ; $C_9H_8O_5$ requires C, 55·1; H, 4·1%.) The yield of acid from 1 g. of γ-resorcylic aldehyde was 0·6 g.

4-H*ydroxy-Coumarone.*—The above acid (1·0 g.) was mixed with a anhydrous sodium acetate (3·0 g.) and acetic anhydride (8·0 g.) and the mixture heated under reflux for about 20 minutes at a temperature of 150°. It was then cooled in ice and diluted with water. The brown liquid product that separated out was extracted with ether. After evaporation of the ether, the residue was treated with sodium hydroxide solution (10 c.c. of 5% solution) and just heated to boiling. The resulting clear solution was then cooled in ice and acidified with excess of dilute hydrochloric acid, when a light brown liquid began to separate out. It was ether extracted; the ether solution was dried over anhydrous calcium chloride and dry petroleum was added until no more coloured impurity separated and the solution was clear. On evaporating the solvents, a pale brown highly viscous liquid separated out which set into a mass of crystals on standing for several weeks. The yield was 0·46 g. and the sample could be directly used for conversion into karanjic acid according to the procedure adopted by Harper.[7] But it was still contaminated with a little coloured impurity. Further purification could be effected by adopting one of the following

processes : (1) distillation *in vacuo* yields a pure product, but it is not suitable for small quantities ; (2) pressing on a porous tile removed impurities and colourless crystals were left, but the loss was great; (3) recrystallisation using low boiling petroleum ether was effected by extracting the coloured sample with the boiling solvent and evaporating the solution almost to dryness. The liquid residue obtained from (3) was almost colourless and crystallised on standing for a few days. The solid melted at 58·5-59° and the melting point was not depressed by admixture with a sample of karanjol obtained by the decomposition of karanjic acid. It gave a pink colour with alcoholic ferric chloride.

Summary

The initial stages in the synthesis of karanjin have been reinvestigated. A new synthesis of karanjol starting form γ-resorcylic aldehyde is described. The aldehyde is condensed with bromoacetic ester (1 mol.) in the presence of sodium alcoholate and the product hydrolysed and eventually converted into 4-hydroxy-coumarone by well-known stages. The preparation of karanjic acid from karanjol is made best through the action of sodium methoxide and carbon dioxide. Further stages leading to the synthesis of karanjin have already been described.

REFERENCES

1. Rangaswami and Seshadri .. *Proc. Ind. Acad. Sci.* (A), 1939, **9**, 259.
   Rao and Seshadri .. *Ibid.*, 1940, **11**, 206.
2. Seshadri and Venkateswarlu *Ibid.*, 1941, **13**, 404.
3. Reichstein .. *Helv. Chim. Acta.*, 1933, **8**, 126.
4. Limaye .. *Rasayanam*, 1937, 119.
5. Shah and Lailwalla .. *J. C. S.*, 1938, 1828.
6. Limaye .. *Rasayanam*, 1936, 14.
7. Harper .. *J. C. S.*, 1939, 1427.

CONSTITUTION OF KANUGIN—PART I

BY S. RANGASWAMI AND T. R. SESHADRI

(From the Departments of Chemistry and Chemical Technology, Andhra University, Waltair)

Received December 14, 1942

THE isolation of kanugin, a new crystalline compound from the roots of *Pongamia glabra* has been described recently.[1] It melts at 197-98° and has the molecular formula $C_{19}H_{18}O_7$. It is a neutral compound and does not contain any phenolic hydroxyl groups. It however has three methoxyl groups and seems to be a completely methylated compound. Since it gives a deep red colour by reduction with magnesium and hydrochloric acid it may belong to the group of methoxyflavones. It has now been found to be feebly toxic to fish. The results of some experiments carried out with a view to understand the constitution in greater detail are described in the present communication.

Demethylation of kanugin by boiling with hydriodic acid in the absence of air gave a sparingly soluble yellow crystalline compound which did not melt below 310° and which had the probable formula $C_{16}H_{12}O_7$. Its ready solubility in cold dilute sodium hydroxide and the formation of an olive brown colour with ferric chloride, a red precipitate with neutral lead acetate and a scarlet colour on reduction with magnesium and hydrochloric acid showed it to be a compound of the flavonol group. The rapid colour changes which it exhibited in alkaline buffer solutions of higher pH lent support to this conclusion. But the partial recovery of the compound after aerial oxidation in alkaline solution (50% potash) did not quite fit in with the above view. Probably there is something in the nature of the molecule of nor-kanugin which is compatible with all the above observations and which is not at present clear.

The acetate of nor-kanugin prepared by boiling with acetic anhydride and sodium acetate melted at 198-99° which was almost the same as the melting point of kanugin itself. The interesting observation relating to this compound was that when methylated using dimethyl sulphate and alkali in acetone solution it gave rise to a product which was not identical with kanugin. The new compound melted at 153° and the crystal forms were not identical. It also gave a red colour on reduction with magnesium and hydrochloric acid showing that it belonged to the same general class of compounds (flavones). The formation of a new methyl ether from the acetate could be explained only on the assumption that some

complex changes had taken place during either the demethylation of kanugin or the acetylation or the subsequent remethylation of nor-kanugin. In all probability the treatment of kanugin with hydriodic acid resulted not only in demethylation of the methoxyl groups but in the liberation of certain new phenolic groups which were not present in kanugin.

By the oxidation of kanugin with neutral potassium permanganate in acetone solution two degradation products were obtained. One was identified as *p*-methoxysalicylic acid by a direct comparison with an authentic specimen obtained by the methylation of β-resorcylic acid with dimethyl sulphate and alkali. The other product which was neutral, being insoluble in cold sodium hydroxide, melted at 135-40° and had the formula $C_7H_8O_2$ or $C_{11}H_{14}O_3$. It also contained methoxyl groups. The available quantity of this compound was not sufficient for further characterisation.

The hydrolysis of kanugin with aqueous alcoholic potassium hydroxide gave rise to a considerable yield of an acid which has resisted all attempts at purification so far. It was definitely crystalline in appearance and melted indefinitely in the neighbourhood of 130° and gave a purple colour with ferric chloride. These properties together with the percentage composition (the analysis corresponds to the formula $C_8H_8O_4$) indicated that it was probably an impure sample of *p*-methoxysalicylic acid which, as mentioned above, had been obtained by the oxidation of kanugin. Possibly it was closely associated with another compound of similar composition and similar properties which could not be eliminated by the ordinary methods of crystallisation. The observation that a mixture with *p*-methoxysalicylic acid melted indefinitely between the melting points of the two components is in agreement with the above view.

The following points emerge from the above observations. Kanugin has a general resemblance to the flavones, a group of compounds which are found widely distributed in nature. It has a resorcinol unit in which one of the hydroxyl groups is present in the form of the methyl ether. Treatment with hydriodic acid brings about some complex change possibly involving the breakdown of an oxygen bridge.

Although these results by themselves do not give any definite idea of the constitution of kanugin they are presented now, since as a result of conditions arising out of the war progress is slow and it may take considerable time to get more definite data.

Experimental

Demethylation of kanugin to nor-kanugin.—The compound (0·2 g.) was dissolved in phenol (3 c.c.) and treated with hydriodic acid (d. 1·7, 5 c.c.).

The mixture was heated for two hours in an oil-bath at 150° with a gentle current of carbon dioxide passing through the reaction vessel. It was then diluted with water (25 c.c.) and decolourised with sulphur dioxide. The yellow solid was filtered, washed with water and crystallised from acetic acid containing a few drops of pyridine. The compound thus obtained was a yellow crystalline powder (clusters of needles and narrow rectangular plates) which turned dark at 290° but did not melt below 310° (Found : C, 60·9 ; H, 3.6 ; $C_{16}H_{12}O_7$ requires C, 60.8 H, 3·8%.)

Nor-kanugin was sparingly soluble in alcohol and acetic acid and easily soluble in pyridine. It dissolved readily in cold dilute sodium hydroxide giving a deep green solution. An alcoholic solution of the substance gave a dark olive brown colour with ferric chloride and a red precipitate with neutral lead acetate. Reduction with magnesium and hydrochloric acid in alcoholic solution gave a scarlet colour. On the other hand using sodium amalgam as the reducing agent the following changes were observed : the solution became red after reduction had taken place; on acidifying with concentrated hydrochloric acid the solution became colourless while with a large excess of concentrated sulphuric acid a brown colour was seen. In Bargellini's test greenish blue flocks were first formed; on shaking the test tube the solution was filled with a deep green precipitate which rapidly gave place to a yellowish brown clear solution. The following changes were noticed when small quantities were shaken with buffer solutions of different pH values :

p_H 8·0 Partly dissolved to give a pale yellow solution. Turbid even after 3 minutes. Unchanged after half an hour. Turbid and unchanged even after 48 hours.

p_H 9·2 Dissolved easily on shaking to form a golden yellow solution. Orange tinge after half an hour. Brighter orange after 1 hour. Unaffected even after 48 hours.

p_H 10·4 Yellow solution rapidly changing to green in half a minute. Greenish yellow in one minute. Yellowish brown after 4 minutes. Orange red after half an hour. Brown after 48 hours.

p_H 11·6 Deep yellow solution. Emerald green in 10 seconds. Brownish red in 2 minutes. Red in 4 minutes. Deep scarlet after 10 minutes. Unchanged after 1 hour. Brown after 48 hours (deeper than with pH 10·4).

p_H 12·8 Deep yellow solution. Emerald green in 5 seconds. Very pale yellowish brown in ½ min. Brown red in 1 min. Red in 2 min. Deep scarlet after 5 min. Unchanged after 1 hour.

Brown after 48 hours (same as with pH 11·6). The changes in this case were the same as with pH 11·6 but much quicker.

Nor-kanugin Acetate:

The acetate was prepared by boiling with sodium acetate and acetic anhydride for 4 hours and pouring the mixture into excess of water. The solid was filtered, washed and crystallised from alcohol-acetic acid mixture. Stout needles were obtained but as the mother-liquor was highly coloured another crystallisation was effected with the above solvent mixture ; this time the mother liquor was practically colourless. The substance crystallised as colourless stout needles and melted at 198-99°, with sintering at 193°. A mixed melting point with kanugin was considerably depressed. [Found: C, 60·4 ; H, 4·0 ; $C_{16}H_{12}O_7$ $(C_2H_2O)_3$ requires C, 59·7 ; H, 4·1 ; $C_{16}H_{12}O_7$ $(C_2H_2O)_5$ requires C, 59·3 ; H, 4·2%.]

Methylation of nor-kanugin acetate :

The acetate (150 mg.) was dissolved in acetone (20 c.c.) and treated with methyl sulphate (2 c.c.) and alkali (2 c.c. of 20% sodium hydroxide solution). After shaking for half an hour further quantities of the reagents were added (1 c.c. of each at the end of every half hour). When 6 c.c. of methyl sulphate had been added in all, 4 more c.c. of 20% sodium hydroxide were added and the mixture was left overnight. After refluxing for half an hour the solvent was evaporated. On cooling, a pale brown solid separated which was filtered, washed and crystallised easily from alcohol. Narrow rectangular plates and tablets were thus obtained which melted sharp at 153°.

The new methyl ether was a colourless shining solid appearing as long needles to the naked eye. It was soluble sparingly in cold alcohol and easily in hot alcohol. It dissolved easily in cold concentrated sulphuric and hydrochloric acids to give yellow solutions having a feeble green tinge. It was insoluble in dilute aqueous sodium hydroxide even after boiling for 3 minutes and gave no colour reaction with alcoholic ferric chloride. Reduction in alcoholic solution with magnesium and hydrochloric acid gave a red colour.

Aerial oxidation of nor-kanugin :

The compound (50 mg.) was shaken with 50% aqueous potash (2 c.c.) in the presence of air. The solution which was intense red and opaque in the beginning became less opaque gradually, though there was no great change in the colour. After leaving in an open test tube with occasional shaking for 48 hours it was acidified, ether-extracted and the slightly sticky residue obtained on evaporation of the solvent examined. It was yellow in colour, gave the same reduction test with magnesium and hydrochloric acid as the

original compound and the same reactions with ferric chloride and lead acetate. It showed no tendency to melt when heated up to 310°, and thus appeared to be an impure sample of the original compound.

Oxidation of kanugin with neutral permanganate :

The compound (0·5 g.) was dissolved in acetone (75 c.c.) and an aqueous solution of potassium permanganate (2 g. in 50 c.c. of water) was added during 4 hours with continuous shaking. The solution remained purple in the initial stages but subsequently became turbid and brown owing to precipitation of manganese oxide. Considerable warmth was also developed during the later stages. After leaving overnight the mixture was saturated with sulphur dioxide. A dark coloured oil separated at the bottom, leaving a clear, colourless liquid above. The solvent (acetone) was evaporated from a water-bath (about 20 minutes). At first the coloured oil slowly dissolved but subsequently a white solid separated. After heating for another 15 minutes the mixture was cooled and repeatedly ether extracted, filtering off any insoluble matter. On evaporation of the combined ether extract a yellow mass of crystals was obtained. It was heated with aqueous alcohol and a small quantity of a sparingly soluble substance was discarded. The clear alcoholic filtrate deposited on cooling a very small quantity of a solid which was removed by filtration. Concentration of the residual clear alcoholic solution gave rise to a turbid liquid with a few oily drops. On stirring with a little aqueous sodium bicarbonate the oil dissolved partly leaving a solid (A) behind.

Solid A : *Neutral compound.*—This was filtered, washed and crystallised from aqueous alcohol. Narrow rectangular plates and tablets melting at 135-40° were obtained. The compound was sparingly soluble in hot water and insoluble in sodium bicarbonate and sodium hydroxide. It did not give a ferric chloride colour, but gave tests for methoxyl groups. (Found : C, 68·0; H, 7·1 ; $C_7H_8O_2$ requires C, 67·8 ; H, 6·5%; $C_{11}H_{14}O_3$ requires C, 68·1 ; H, 7·2%.)

Acidic component : *p-methoxysalicylic acid.*—On acidifying the sodium bicarbonate solution (from A above) with hydrochloric acid a colourless solid was obtained. It was crystallised from hot water discarding a small amount of resin and non-crystalline solid which came down on cooling to 80°. The fine shining needles that subsequently separated melted at 155°, appeared as rectangular rods with tapering ends under the microscope and gave a deep purple colour with alcoholic ferric chloride. A comparison with an authentic specimen of *p*-methoxysalicylic acid prepared by methylating β-resorcylic acid with dimethyl sulphate and alkali showed that the two were identical.

Alkali fission of kanugin.—The compound (0·5 g.) was treated with alcohol (25 c.c.), water (25 c.c.) and potassium hydroxide (2·5 g.) and the mixture was heated under reflux in an atmosphere of hydrogen. The solid dissolved slowly in about half an hour giving a clear reddish yellow solution. After boiling for 4 hours and cooling in the atmosphere of hydrogen the solution was acidified with hydrochloric acid, the alcohol distilled off and the residue ether extracted. The ether extract was shaken successively with aqueous sodium bicarbonate (*a*) and dilute sodium hydroxide (*b*) and then evaporated (*c*). The sodium bicarbonate solution (*a*) when acidified gave a copious precipitate of a colourless crystalline solid which was filtered and recrystallised from hot water. Though it was quite crystalline to the naked eye and under the microscope (fine needles) the melting point was not quite satisfactory. It sintered at 122° and melted at 128-30°. Attempts to recrystallise it from various solvents so as to get a sharp melting compound have not so far been completely successful though the melting point could be raised to 145°. It was a carboxylic acid, dissolving easily in cold aqueous sodium bicarbonate to give a yellow solution and it gave a purple colour with ferric chloride in alcoholic solution. (Found: C, 57·7; H, 4·9, OCH_3 17·5 ; $C_8H_8O_4$ requires C, 57·2; H, 4·8, OCH_3 (1), 18·5%.)

(*b*) The sodium hydroxide solution when acidified did not give rise to any solid or liquid. Hence it was extracted with ether and the solvent evaporated. The residue was insignificant and it could not be examined.

(*c*) When the residual ether solution was evaporated, an oil separated in small amount but it did not solidify even after two days. Treatment with phenylhydrazine and acetic acid did not give rise to any definite product.

Summary

By the oxidation of kanugin with potassium permanganate in acetone solution 4-o-methylresorcylic acid (I) and a neutral compound (II) containing methoxyl groups and having the formula $C_7H_8O_2$ or $C_{11}H_{14}O_3$ have been obtained. Hydrolysis with alcoholic alkali yielded an acid which seemed to be impure (I). The presence of a resorcinol unit in the molecule seemed to be thus established. Demethylation of kanugin gave rise to nor-kanugin. It had the properties of a flavonol ($C_{16}H_{12}O_7$) and gave bright colours in alkaline buffer solutions. When its crystalline acetate was methylated a new methyl ether which was different from kanugin was produced. It was therefore concluded that by the action of hydriodic acid, besides demethylation some other changes were brought about.

REFERENCE

1. **Rangaswami and Seshadri** .. *Proc. Ind. Acad. Sci.*, A, 1942, **16**, 319.

CHEMICAL COMPONENTS OF INDIAN TULIP (*THESPASIA POPULNEA*) FLOWERS

By K. Neelakantam, P. Suryaprakasa Rao
and
T. R. Seshadri
(*From the Department of Chemistry, Andhra University, Waltair*)

Received December 14, 1942

Thespasia populnea, the Indian Tulip or the Portia tree is a fair-sized ever-green tree which flowers throughout the year. The flowers are highly showy and attractive. They are sulphur-yellow in colour with a purple centre and are nearly three inches in diameter.

These flowers have been examined in these laboratories from time to time according to the general procedure adopted for the study of flower-pigments. The dried petals are extracted with alcohol, and the extract concentrated. The pigment that separates out from this alcoholic concentrate is designated as "alcoholic fraction". After the removal of this fraction, the concentrate is diluted with a large volume of water and again concentrated to a small bulk. Pigment separating out from this aqueous liquor is called "aqueous fraction". The mother-liquor left is first extracted with ether and the extract evaporated to yield the "ether fraction". It is then treated with neutral lead acetate and subsequently with basic lead acetate, and the substances produced by the decomposition of these two lead salts are called "the neutral" and "the basic lead acetate fractions" respectively.

A preliminary study of the dried petals of *T. populnea* obtained in October 1933 from Coimbatore was made by Neelakantam and Seshadri.[1] Both the alcoholic and the aqueous concentrates did not yield any pigment. Neutral lead acetate gave only a small amount of a red precipitate, while the basic lead acetate produced a bulky orange-yellow solid. From the last fraction were isolated three compounds : (1) a small quantity of a yellow glycosidic substance which melted at 228–30° (decomp.), (2) a fairly good amount of a non-glycosidic pigment melting at 270–75°, and (3) a very small quantity of a third pigment which was present in the neutral lead acetate fraction also and which could be obtained pure only in the form of its acetyl derivative melting at 182–85°. Substance (1) on hydrolysis with sulphuric acid produced glucose and an aglucone which was found to be

identical with substance (2). The glucoside and its aglucone were named Populnin and Populnetin respectively.

Another sample of the flowers procured from the Trichinopoly district during the summer of 1936 was examined by the same authors[1] and these were shown to contain only the glucoside, populnin which was isolated from the basic lead acetate fraction.

A third sample of the flowers secured from the same place in summer 1939 was studied by Rao and Reddi.[2] This time the pigment was isolated in the form of the aglucone. Since the alcoholic and the aqueous concentrates did not yield any compound, the aqueous solution was boiled with acid and extracted with ether. The aglucone obtained from the ether extract was found to be entirely different from populnetin and was identified as the tetrahydroxy flavonol, herbacetin. It was also shown that the acetyl derivative of the third pigment (substance 3) prepared by Neelakantam and Seshadri from the 1933 sample of flowers was identical with herbacetin acetate.

It is, therefore, clear that populnin, populnetin and herbacetin occur in the flowers of *Thespasia populnea*, but their relative proportions vary considerably depending upon the season. Besides these three yellow pigments, a new colourless compound designated "Populneol" is also present in appreciable amounts.

A large sample of the flowers collected in January 1940 from Trichinopoly has been found to contain all the four entities, and the results of a close and careful examination of this sample are described in detail in this paper. No pigment separated from the alcoholic concentrate. From the aqueous fraction was obtained mainly populnin; and the ether extract of the aqueous mother-liquor gave populneol. From the neutral lead acetate fraction a small quantity of herbacetin was isolated while the basic lead acetate fraction yielded some amount of populnetin.

There was some difficulty in understanding the composition and chemical nature of populnetin and populnin. This was due partly to the accompanying impurities and mainly to the capacity of populnetin and its derivatives to hold water of crystallisation rather tenaciously. The original suggestion of Neelakantam and Seshadri that they are anthraquinone derivatives[1] is not correct. It is now definite that populnetin is a tetrahydroxy flavone and populnin is its monoglucoside.

Populnetin has the formula $C_{15}H_{10}O_6$. With ferric chloride it gives a pale green colour and with basic lead acetate a yellow precipitate. It dissolves in concentrated sulphuric acid with a characteristic green fluorescence.

When reduced with magnesium and hydrochloric acid, it yields a brownish red solution. If, however, the reduction is effected with sodium amalgam and alcohol, and the solution acidified, a deep red colour results. When the Wilson boric-citric acid test[3] is carried out with an acetone solution of the substance, it is positive for the presence of a hydroxyl group in the 5th position. With alkaline buffer solutions it does not exhibit any prominent colour changes. It is, therefore, taken to be a hydroxy flavone. On acetylation it produces a tetra acetyl derivative which like the acetate of kæmpferol exhibits dual melting point; it undergoes vigorous dehydration at about 130° and finally melts at 242–44°.

Populnin resembles its aglucone very closely in its reactions. Ferric chloride imparts a dull green colour to an alcoholic solution of the substance and basic lead acetate produces a yellow precipitate. Like populnetin the glucoside also gives a green fluorescence in concentrated sulphuric acid solutions. With alkaline buffer solutions it does not exhibit any display of colours.

Populneol is a colourless crystalline substance melting at 116–18° and it has the molecular formula $C_{15}H_{12}O_3$. It is phenolic in nature since it dissolves in aqueous alkali, and gives a brownish violet colour with ferric chloride. It forms a yellow solution in concentrated sulphuric acid without any fluorescence.

The final constitutions of populnetin, populnin and populneol are under investigation.

Experimental

Isolation of Populnin.—The dry petals of the flowers (3 kg.) were extracted with boiling methylated spirit in batches and the combined extract was concentrated to a small bulk. After filtering off through fluted filters the tarry impurities that separated out, the clear concentrate was allowed to stand. As no pigment was deposited from this solution even after a long time, it was diluted with a large volume of water, alcohol was evaporated and the solution concentrated to a small bulk (500 c.c.) on a water-bath. During this operation large amounts of a crisp pink coloured resin separated out and it was removed. From the clear aqueous liquor a yellow solid began to crystallise out after four months and the deposition was almost complete after six months. The solid was filtered and purified by crystallisation first from aqueous pyridine and then from alcohol. It was finally crystallised from dilute acetic acid, when it appeared as short yellow needles melting at 228–30° (decomp.). The pure compound was obtained in an yield of 10 g. (0·3%). (Found: C, 54·4 ; H, 4·6 ; $C_{21}H_{20}O_{11}$, H_2O requires C, 54·1, H·4·7%.)

Isolation and properties of Populneol.—The mother-liquor left after the filtration of populnin was repeatedly extracted with ether. After distilling off the solvent the extract left behind a brownish oily liquid which became a solid on the addition of a little water. It was filtered but was found to be still pasty and brownish. It was, therefore, pressed on a porous plate when almost all the brownish oily impurity was absorbed by the plate, leaving behind a light brown dry solid. When the latter was crystallised from dilute alcohol, colourless rectangular plates melting at 116-18° were obtained. The yield was 5 g. (Found: C, 74·7 ; H, 5·4% ; m.wt. by Rast's method 228, 230; $C_{15}H_{12}O_3$ requires C, 75·0; H, 5·0% and molecular weight, 240.)

The compound was sparingly soluble in water but freely dissolved in alcohol and acetic acid. It was soluble in dilute sodium hydroxide but not in carbonate or bicarbonate solution. With ferric chloride it gave a brownish violet colour, and with concentrated sulphuric acid a yellow solution without any fluorescence.

Isolation of Herbacetin:—The aqueous solution left after the extraction of populneol was treated with excess of neutral lead acetate solution. Immediately a brownish orange precipitate was formed. It was separated, suspended in water and decomposed with hydrogen sulphide in the usual manner. The aqueous solution obtained thereby contained a great deal of impurities and no pigment separated out even after four months. It was, therefore, made 7% acid by the addition of the requisite amount of concentrated sulphuric acid, and boiled under reflux for two hours. During this hydrolysis the resins began to float up and stick to the walls of the flask. After the boiling was over, the clear liquid was carefully decanted and after cooling ether-extracted. A small amount (1 g.) of a yellow pigment was obtained. After recrystallisation from alcohol it melted at 282–85°. It was identified as herbacetin from a study of its colour reactions with alkaline buffer solutions and a comparison of its acetyl derivative with a pure sample of acetyl herbacetin melting at 193–95°.

Isolation of Populnetin : (*a*) *From basic lead acetate fraction.*—The mother-liquor left after the removal of the neutral lead acetate precipitate was treated with basic lead acetate when a bulky yellow precipitate was obtained. It was decomposed and worked up as in the case of the neutral lead acetate fraction. About 2 grams of populnetin melting at 274–76° were obtained.

(*b*) *By the hydrolysis of populnin.*—When the glucoside was boiled with 7% sulphuric acid under reflux it went into solution during the course of half an hour. Within an hour yellow populnetin separated out, but

the boiling was continued for another hour to complete the hydrolysis. After cooling the contents were filtered, and the solid recrystallised from alcohol to obtain a pure sample.

The filtrate was examined for sugar by first neutralising it with barium carbonate, concentrating the neutral solution to a small quantity and finally treating it with phenyl hydrazine in dilute acetic acid solution. Glucosazone was obtained and was identified from its characteristic crystal structure and melting point.

If produced from impure samples of the glucoside, populnetin was always contaminated with herbacetin. The crude pigment could, however, be purified by dissolving in 50% potash, keeping the solution exposed to air for 24 hours and acidifying. By this treatment the flavonol herbacetin was decomposed leaving behind populnetin. Frequently it was still impure due to admixture with resins. It was dissolved in a mixture of acetone and ether, and when petroleum ether (B.P. 60-80°) was added to this solution the impurities separated out first. After sometime, the clear supernatant liquid was carefully decanted and evaporated, when pure populnetin was obtained. On crystallisation from aqueous alcohol it came out as fine needles with a dull yellow colour and melted at 278–80°. [Found : loss on drying at 110° *in vacuo* (H_2O), 6.2%. $C_{15}H_{10}O_6$, $1\frac{1}{2}H_2O$ requires for loss of 1 H_2O 5·8%. Found in the sample dried at 110° *in vacuo*: C, 61·5; H, 3·4; $C_{15}H_{10}O_6$, $\frac{1}{2}H_2O$ requires C, 61·0; H, 3·7%.]

Properties of Populnin and Populnetin.—Populnin and populnetin resembled very closely in many respects. Both of them gave no precipitates with neutral lead acetate but yielded yellow precipitates with basic lead acetate. In both cases ferric chloride imparted a dull green colour to alcoholic solutions of the substances. They dissolved in concentrated sulphuric acid to produce yellow solutions with a characteristic green fluorescence which became more prominent on adding more acid. Neither of them displayed any colour changes with alkaline buffer solutions. They merely dissolved to form yellow solutions. However, they differed slightly in their reactions towards alkalis. Populnin readily dissolved to produce a deep yellow solution, whereas populnetin gave a bright red colour with strong alkali, and it changed to brownish yellow on dilution. If contaminated even with traces of herbacitrin or herbacetin, the yellow solution rapidly assumed a greenish tinge and gradually faded to brownish yellow.

When reduced with magnesium and hydrochloric acid, populnetin gave a brown-red solution. If, however, sodium amalgam was used for the reduction of the substance dissolved in alcohol, and the solution was then acidified, a deep red colour was produced. On acetylation

with acetic anhydride and anhydrous sodium acetate, tetraacetyl populnetin was formed. The acetyl derivative seemed to undergo some decomposition when boiled with either alcohol or acetic acid. It could best be recrystallised by dissolving in a small amount of acetic anhydride, adding an equal amount of absolute alcohol and allowing the solution to stand. After a few days, it appeared as long narrow rectangular plates. It crystallised as a hydrate, and on rapid heating, it lost the water of hydration at about 128–30°. The dehydration was so rapid and vigorous with swelling and shooting up of the material that it could be easily mistaken for more serious decomposition of the substance. If the heating was, however, slow and controlled, the compound merely shrank from 124–134° losing the water of hydration which could be seen condensing in the melting point tube above the shrunken mass, became a brownish glassy solid at a higher temperature and finally melted into a clear liquid at 242–44°. (Found in the air-dried sample : C, 59·3 ; H, 4·2 ; loss (H_2O) on heating 2·0% ; $C_{15}H_8O_2(OCOCH_3)_4$, $\frac{1}{2}H_2O$ requires C, 59.6 ; H, 4·1 ; loss of H_2O on heating 1·9%.)

Summary

A sample of the flower-petals of *Thespasia populnea* is found to contain populnin (0·33%), populnetin (0·07%) and herbacetin (mostly as its glucoside, 0·03%). The proportions vary with different samples depending on seasonal and other factors. Besides these three yellow pigments, a colourless phenolic compound called populneol is also present (0·16%).

Populnetin seems to be a new tetrahydroxy flavone and populnin is its monoglucoside.

REFERENCES

1. Neelakantam and Seshadri *Curr. Sci.*, 1938, **7**, 16.
2. Rao and Reddi .. *Proc. Ind. Acad. Sci.*, (A), 1940, **12**, 372.
3. Rangaswami and Seshadri .. *Ibid.*, 1942, **16**, 129.

1375-42 Printed at The Bangalore Press, Bangalore City, by G. Srinivasa Rao, Superintendent
and Published by The Indian Academy of Sciences, Bangalore.